

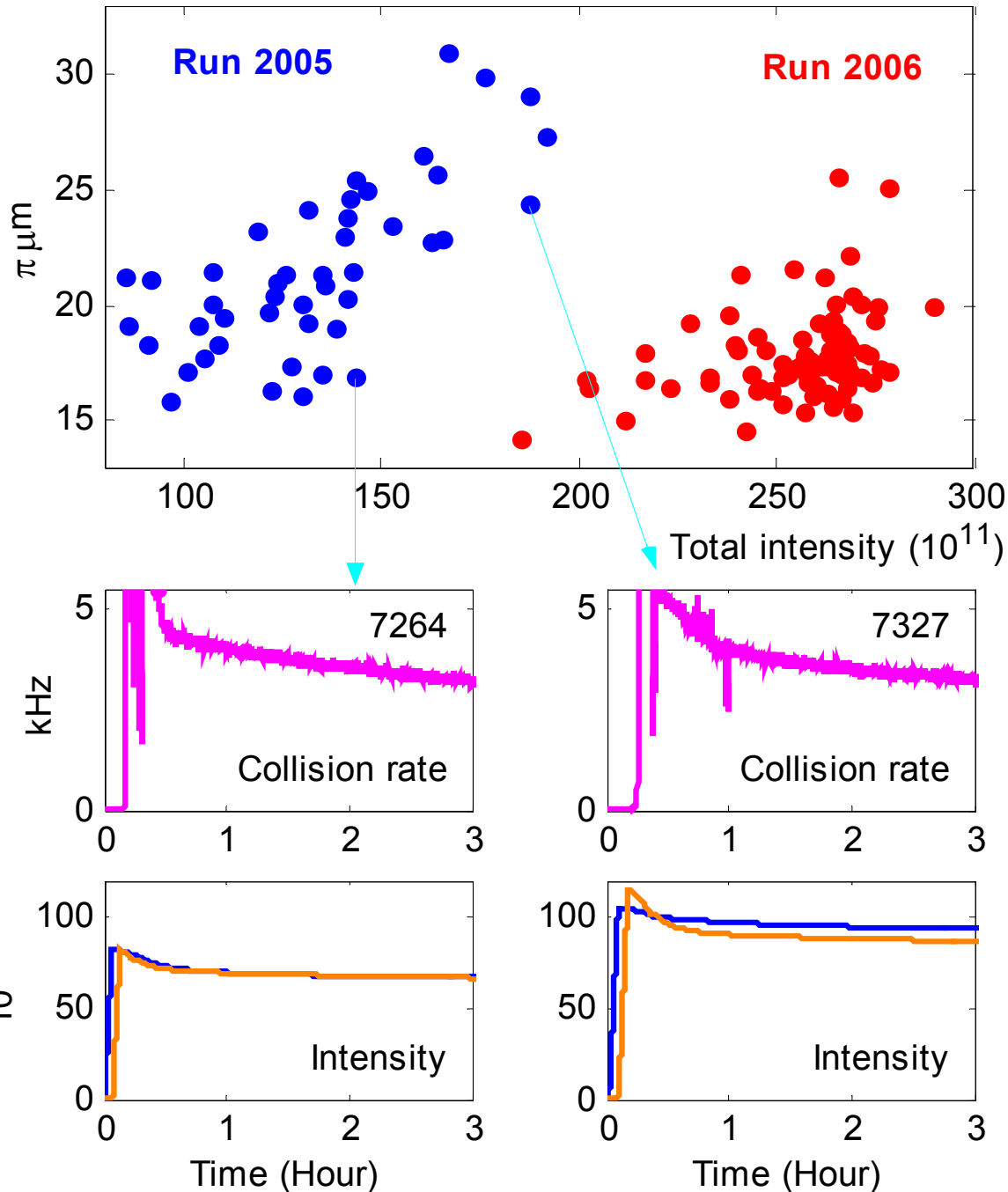
# Electron Cloud and Emittance in RHIC

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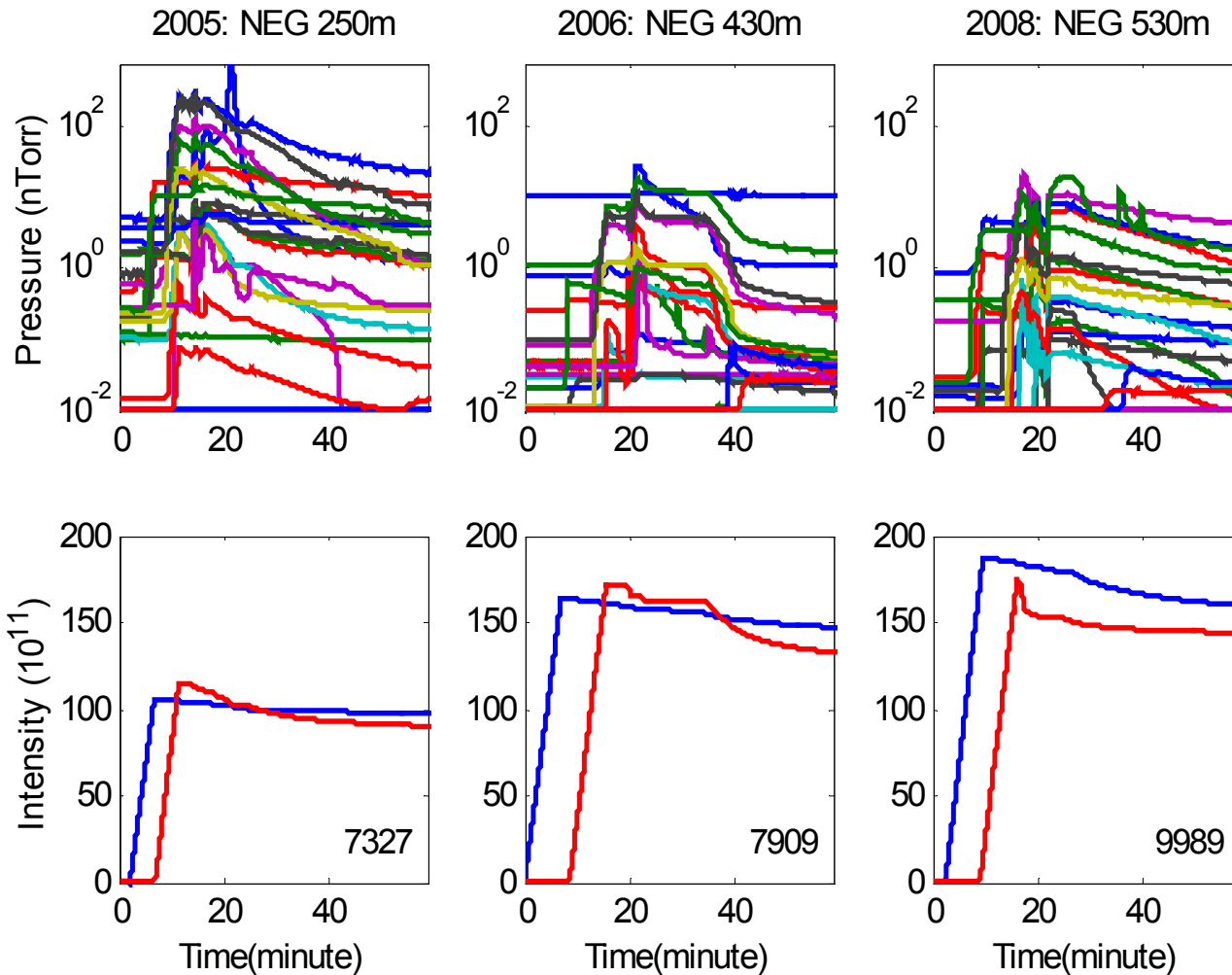
- In proton run 2005, the emittance growth at RHIC injection and acceleration has a dependence on dynamic pressure rise, which is caused by electron cloud.
- The emittance growth in 2006 and 2008 proton runs is smaller. Average electron density in rings is lower, partly due to additional 180 m (2006) and 100 m (2008) NEG pipes.
- RHIC upgrade calls for at least 30% higher intensity, 40% and 70% shorter bunches at store for 9 MHz and 56 MHz scenarios. The emittance growth may be of concern.

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## Emittance at early store

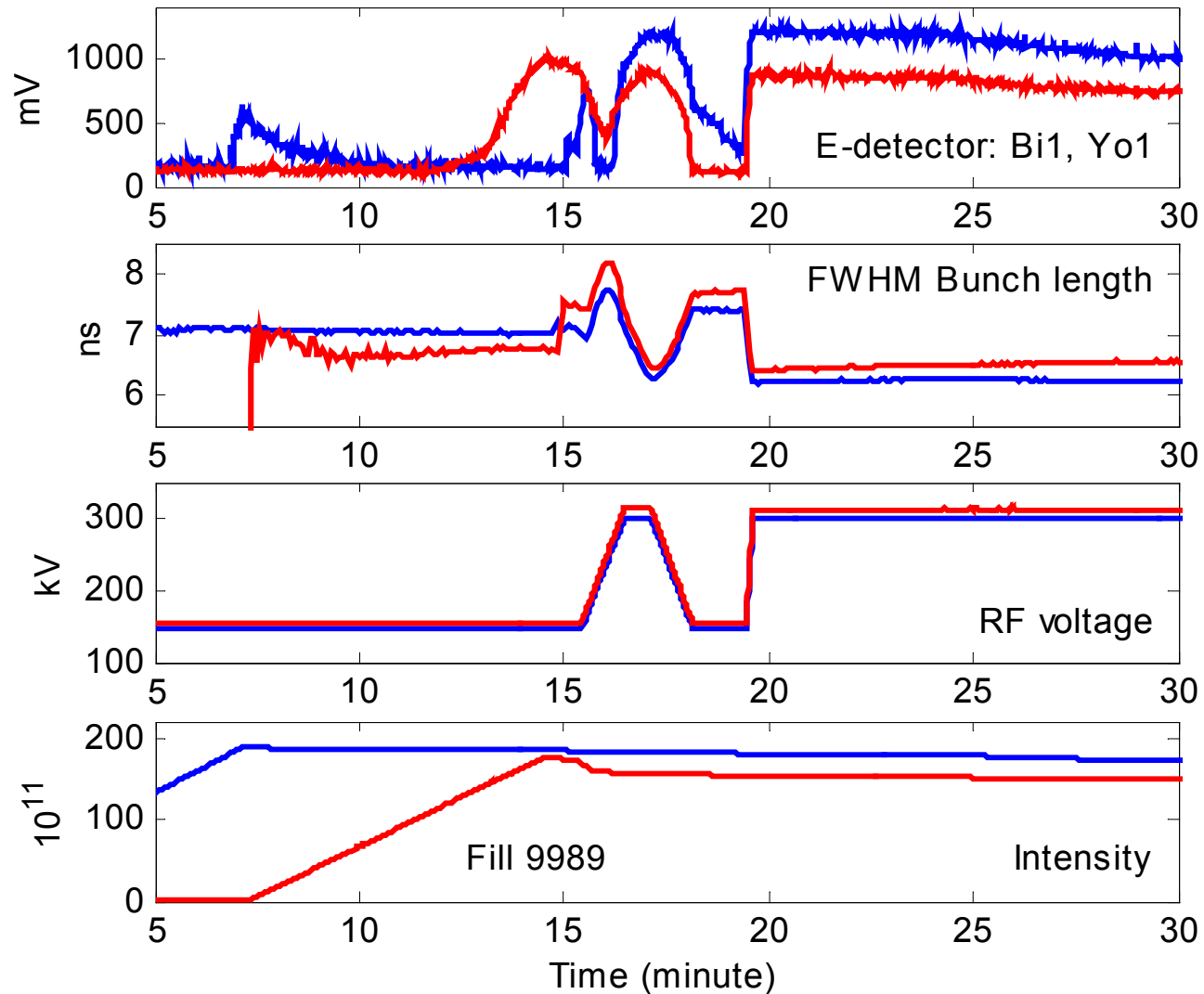


- In RHIC polarized proton run 2005 (pp05), the beam emittance at early store has a dependence on dynamic pressure rise, which is caused by electron cloud.
- As a result, fill 7264 with  $142 \times 10^{11}$  protons had luminosity  $11.1 \times 10^{30}/\text{cm}^2\text{s}$ , 7327 with  $187 \times 10^{11}$  protons had  $10.2 \times 10^{30}/\text{cm}^2\text{s}$ .
- The beam intensity in pp06 and pp08 is higher, but the overall dynamic pressure rise is lower. Therefore, the electron cloud induced emittance growth is less concerned.



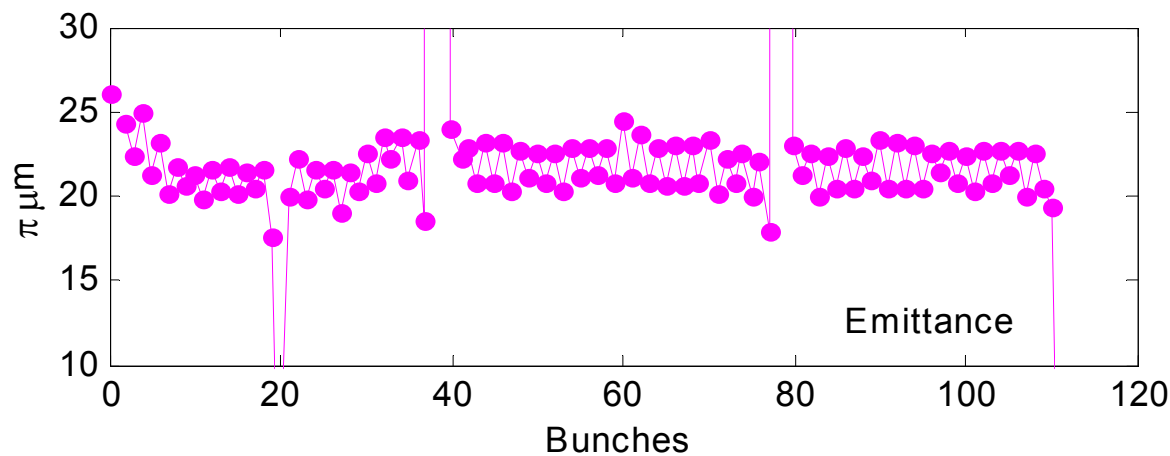
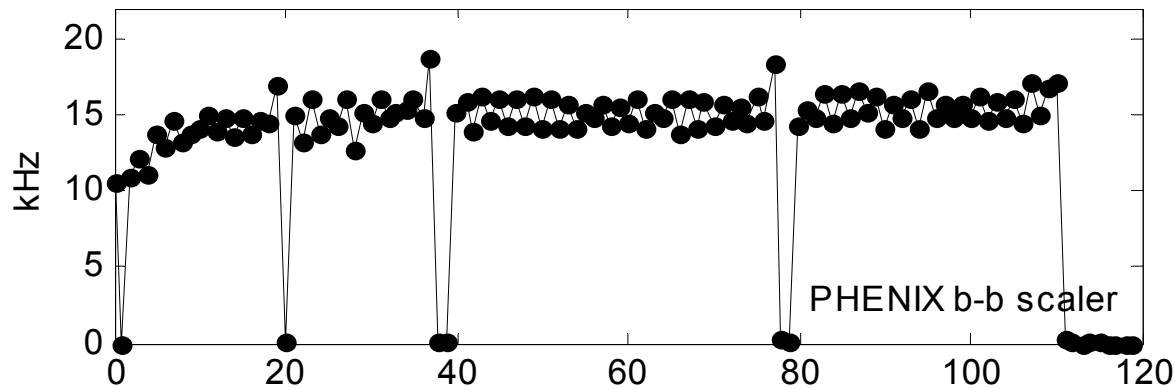
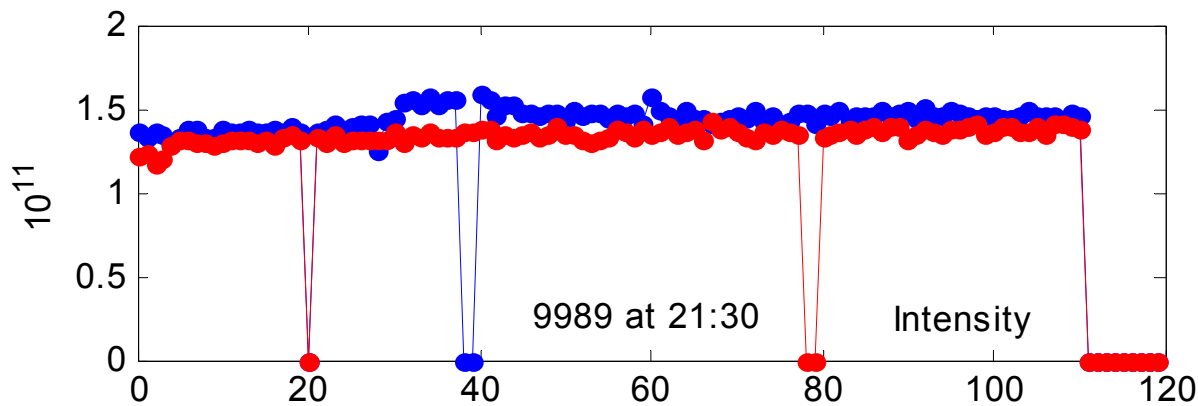
- Beam is affected by the overall electrons in rings, so average electron density is calculated for study.
- When a bunch passed, all electrons hit the wall and the electron desorption → gas molecules → pressure rise.
- Average e-density of  $\gtrsim 2 \times 10^{10}/\text{m}^3$  seems harmful. Examples are 7327 (pp05) and 7935 (beam study in pp06). In pp06 and pp08 operations, e-density only reached  $\sim 0.2 \times 10^{10}/\text{m}^3$ .

Run	2005		2006		2008
NEG pipes m	250		430		530
Fill	7250	7327	7909	7935	9989
Bunches	78	106	111	111	106
B/Y intensity 10 <sup>11</sup>	74/73	109/109	164/172	206/205	187/175
Ave. e-density 10 <sup>10</sup> /m <sup>3</sup>	0.24	2.2	0.22	1.7	0.17
Emit. growth $\pi\mu\text{m}$	~ 0	11	~ 0	12	~ 0



- In pp08, RF voltage raised at store to shorten bunches, electron multipacting is enhanced.
- RHIC upgrade plan calls for shorter bunches at store. Electron cloud effect may need attentions.
- The 9 MHz scenario plans to keep the small longitudinal emittance, then to use 28 MHz for store. Peak current at early store will be 2 times higher than pp08.
- The 56 MHz at store will have 3 times of peak current.

<i>100 GeV store</i>	<i>RF Voltage</i> MV	<i>Longi. Emit.</i> eVs	<i>Bunch Length</i> ns	<i>Bunch Intens.</i> $10^{11}$	<i>Peak Current.</i> A	<i>Moment. Spread</i> %
<i>Run 2008</i>	0.3	2.0	13	1.5	3	0.09
<i>9 MHz - 28 MHz</i>	0.3	0.7	7.7	2	6.6	0.06
<i>9 MHz - 56 MHz</i>	2	0.7	4	2	13	0.11



- The bunch-bunch scaler can be used to study the electron cloud effect (also for beam-beam, injection kicker, and gap cleaner effects).
- Example of the PHENIX bunch-bunch scaler of Fill 9989. The bunch emittance calculated from the 4 minutes b-b scaler seems promising.
- The bunch-by-bunch ZDC structure is not understood. The sum of the ZDC account of all 106 bunches is about 2/3 of the PHENIX ZDC. Why the head bunches have larger emittance?